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(54) Soldering surface mounted devices to flat surfaces

(57) An apparatus for soldering surface mounted devices to flat substrates uses a temperature-resistant hydrocarbon fluid both as a heat- and a solder-transfer medium. The fluid is heated to a temperature above the melting point of the solder, and a suspension of droplets of molten solder is formed in the fluid by mechanical means. Jets of this suspension are directed against the joints to be soldered, surplus solder being removed subsequently by further jets of hot, solder-free fluid, the assembly being fully immersed in the fluid during this procedure. Afterwards, the assembly is removed from the hot fluid, adhering fluid being removed by jets of air and recovered.

By the same principle, circuit boards with plated-through holes can be given a uniform coating of solder, the bores of the holes remaining free of solder.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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SPECIFICATION

Method of soldering surface-mounted devices

I) Object of the invention

a)Soldering surface-mounted electronic devices such as resistors, capacitors, triodes, or integrated circuits mounted in packages or circuit-carriers to substrates such as printed circuit boards or ceramic wafers, both of which carry a pattern of solderable surface elements (Footprints).

b) Coating such footprints, or complete printed circuit boards with plated-through holes with solder, prior to soldering.

II) Present state of the art

At present, several methods are used to achieve object Ia:

a) Securing the surface-mounted devices on the substrate with a heat- or UV curable adhesive so that their solderable surface elements or leads are juxtaposed to the substrate footprints sufficiently closely that, when they are brought into contact with molten solder (mostly containong 60% tin, 40% lead, and melting between 183° and 190°C), having been coated with soldering flux previously, soldered joints are formed between these surfaces or leads, and the footprints. The molten solder is offered to the joints in the form of a pumped, stationary wave of solder, usually of a temperature of 250°C, or a succession of waves, the circuit boards moving through the crests of these waves with the components and the footprints on the underside of the board.

b) Depositing a mixture of finely powdered solder and soldering flux (known as soldercream) on the footprints, e.g. by screen printing, placing the devices on the substrate so that their solderable surfaces or leads are pressed against the cream-coated footprints, and subsequently heating the assembly to a temperature above the melting point of the solder, by placing it on a hotplate, passing it through an oven heated by various means, or placing it in a volume of saturated vapour of a high-boiling fluoro- or chlorofluoro-hydrocarbon liquid, usually one with a boiling point of approx. 215°C. At this temperature, the solder contained in the cream melts and completes the joint, aided by the flux present in the cream. This method is known as vapourphase soldering.

III) Limitations of the present art

Increasing miniturisation of circuitry leads to ever closer distances between neighbouring footprints. At present, these distances can be as small as 0.2 mm, the footprints being 0.3mm wide. Present and future developments tend to require still closer spacing and smaller footprints. On the other hand the methods of wavesoldering, and the screenprinting of solder-cream have reached the limits of their capability of covering and soldering such fine patterns with the required reliability.

IV) Proposed novel method

It is proposed to offer the molten solder to the joint surfaces in the form of a moving suspension of finely divided droplets of molten solder or of fine jets of molten solder, dispersed in a suitable hydrocarbon liquid of high temperature stability (e.g. Galden 'LP', marketed by Montedison U.K. Ltd) which withstands temperatures up to 300°C without boiling or decomposition. The proposal is however not limited to the use of this specific material.

V) Putting the method into effect

To achieve Object (a), i.e. Soldering

The hydrocarbon liquid is contained in a vessel made from stainless steel or titanium and heated to a suitable soldering temperature, e.g. 250°C. Within the volume of liquid, moving streams or jets of the liquid are created by pumping the liquid through an array of round or elongated nozzles. Molten solder is injected into these streams or jets by pumping it from a sump in the bottom of the vessel at a suitable rate into the stream of liquid hydrocarbon issuing from the above nozzles. The hydrocarbon, having a density of between 1.8 - 2.0 and moving with sufficient speed, has enough kinetic energy to carry the solder with it.

The circuit boards, carrying the surface-mounted devices, are passed close to the nozzle or nozzles for the molten solder in the stream to impinge upon the joints and fill them. In order for this to take effect, all joint surfaced have to be rendered well solderable by known means, and the devices have to be secured to the substrate by adhesive, as for wavesoldering.

A preferrd arrangement is for the boards to travel past the stream of solder-carrying hydrocarbon horizontally, with the surface carrying the devices facing downward, but alternative arrangements can be used for soldering boards carrying devices on both sides. Alternative methods of injecting molten solder into the streams of moving hydrocarbon is to create a suspension of fine droplets of sonder by fast rotating paddles or by ultrasonic energy.

Surplus solder, not retained in the completed joints, sinks to the bottom of the vessel and returns to the solder well.

Having passed the soldering jets or streams, the soldered boards move past one or more cleaning jets of the same hydrocarbon liquid, which carry no solder, and which are located in the same vessel. These jets remove surplus solder from the joints, clear bridges of solder between adjacent joints, and remove droplets of solder lodged under devices or elsewhere, thus avoiding the condition known as 'solderballing'. It should be pointed out, that all these jets and movements of liquid hydrocarbon are located within the volume of the liquid, below its surface.

The circuit boards to be soldered are preferably moved through the soldering vessel along a horizontal path, with sloping entry and exit, surplus hydrocarbon being blown off the emrging boards and back into the vessel, with jets of compressed air.

To achieve Object (b), i.e. Tinning

This object comprises the coating with solder of the footprints, and if required also of parts of the conductor pattern on the substrate and of the inside of plated through-holes. This purpose can be achieved with the same apparatus, passing the boards to be coated between sets of opposing nozzles, which guide the solder-carrying streams against the boards. Solder retained in plated through-holes is subsequently cleared by passing the boards between sets of solder-free hydrocarbon jets, directed against both sides of the board, and offset against one another in a manner known from the socalled 'Hot-Air Levelling Process'.

CLAIMS

1. An apparatus for the soldering of surface-mounted devices to flat substrates, using a hydrocarbon fluid, which is resistant to normal soldering temperatures, as a heat- and solder-transfer medium, the solder forming a suspension of molten droplets in one or more streams or jets of the said hydrocarbon fluid, which impinge against the joints to be soldered, the fluid being heated to the soldering temperature appropriate for the solder being used.

2. An apparatus as claimed in Claim 1, wherein the solder used is a normal tin-lead solder requiring a soldering temperature between 200°C and 250°C, or a lower-melting solder such as a tin-bismuth solder permitting a soldering temperature below 180°C, or a higher-melting lead-rich solder requiring a soldering temperature not below 320°C.

3. An apparatus as claimed in Claims 1 and 2, wherein the suspension of solder droplets in the hydrocarbon fluid is created by feeding the molten solder into the moving fluid upstream of the pump or impellor which propells the fluid against the assembly to be soldered.

4. An apparatus as claimed in Claims 1 and 2, wherein the suspension of solder droplets in the stream or jet of hydrocarbon fluid is created by introducing the molten solder through a nozzle or annulus directly into the discharge nozzle which projects the said fluid against the joints to be soldered.

5. An apparatus as claimed in Claims 1, 2, 3 and 4, wherein the said discharge nozzles are located below the surface of the fluid in the vessel containing the working fluid.

6. An apparatus as claimed in claims 1 to 5, wherein the assembly to be soldered is moved past the said discharge nozzles in a horizontal position, the nozzles being located below and/or above the assembly.

7. An apparatus as claimed in Claims 1 to 5, wherein the assembly to be soldered is moved past the said discharge nozzles in a vertical position, the nozzles being located facing one or both sides of the assembly.

8. An apparatus as claimed in Claims 1 to 7, wherein the assembly, having been moved past the discharge nozzles and all the joints having been filled with solder, the assembly moves past a second set of nozzles, projecting solder-free hot hydrocarbon fluid against the said assembly, thus removing surplus solder from the soldered joints and from elsewhere, where its presence would be undesirable.

9. An apparatus as claimed in Claim 8, wherein the assembly moving past the said nozzles consists of a printed circuit board, with plated-through holes, but not carrying any components, and wherein the second set of nozzles removes surplus solder deposited on the solderable surface elements and remaining inside the bore of the plated-through holes, such solder having been first deposited in these locations on the board by the first set of discharge nozzles as claimed in Claims 1 to 5 and in Claim 7.

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